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NOTE

Activation Cross Sections for Reaction Leading to Long-lived Reaction Products on Iron, Cobalt, Nickel, Zirconium and Molybdenum for 14.6 MeV Neutrons

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The investigations on the interaction of 14 MeV neutrons with structural materials are very important for the design of the fusion reactor. Many workers[1] have measured the activation cross sections for 14 MeV neutrons. However relatively a few data have been reported for the reactions leading to the long-lived nuclei. Therefore we have undertaken to measure the reaction cross sections leading to the long-lived nuclei on Fe, Co, Ni, Zr and Mo, which are most important structural materials of the fusion reactor, for 14.6 MeV neutrons with a shielded Ge(Li) detector.

Experimental procedures were similar to those of a previous investigation,[2] so that they are described only briefly here. Natural metal samples of about 1 gr of Fe, Ni, Zr and Mo were used. About 0.6 gr of sample powder of Co was pressed into plastic cups so that it acquired a cylinder from 14 mm in dia. and about 3 mm thick.
Thin Al-foils of about 50 mg were placed in the front and back of the samples.

The neutron irradiation times are about 2 h. After cooling periods of 5～30 d in which short-lived activities had decayed, the γ spectra of long-lived activities were measured for periods of 8～24 h with a 118 cm^3 coaxial Ge(Li) detector shielded with iron-plates of 150 mm thick and copper-plates of 20 mm thick. By the use of this shield, background counting rate was markedly reduced.

The $^{27}Al(n, \alpha)^{24}Na$ reaction with a cross section of 114.5 ± 4 mb[3] was used as the monitor. The activities of Al were measured after several hours from the end of neutron irradiation.

Typical gamma energy spectrum is shown in Fig. 1. Table I shows the results obtained from the present work, together with the half-lives[4] of the products, the γ-ray energies[4] and the number[4] of γ quanta emitted per disintegration used in the calculation of the cross sections.

The (n, p) and (n, α) cross sections predicted from the empirical formulas proposed by Kumabe and Fukuda[5,6] are also shown in Table I. The predicted values except

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for ^{98}Mo(n, α) reaction are in fairly good agreement with the present experimental cross sections.

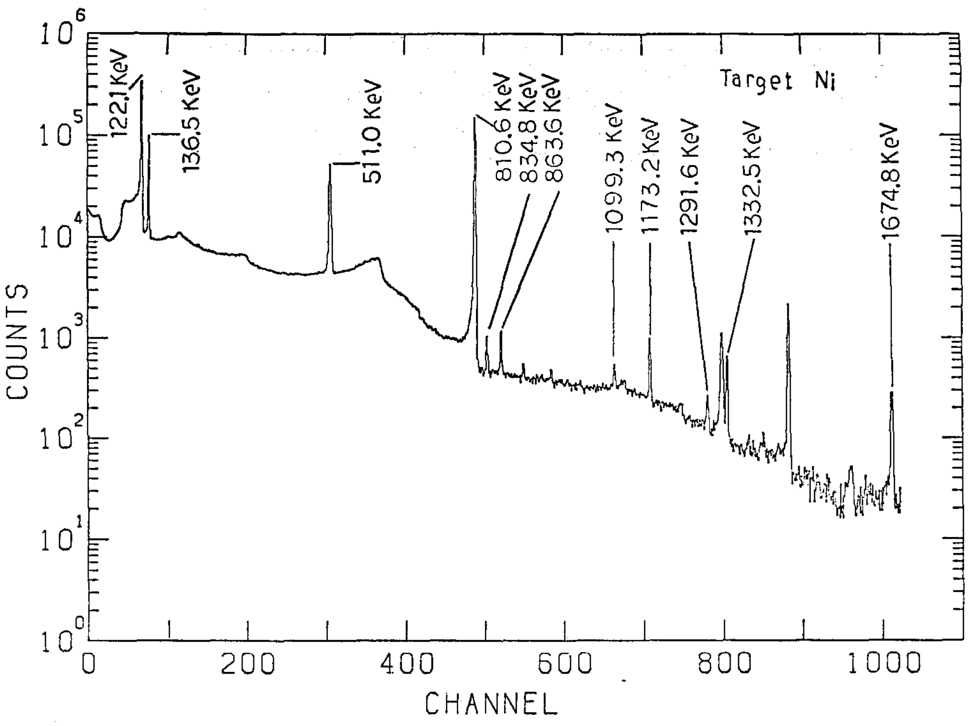

Fig. 1. Gamma energy spectrum for nickel target after cooling period of 20 days.

Table I. Cross sections for (n, p), (n, α), (n, $2n$) and (n, np) reactions with 14.6 MeV neutrons.

Reaction	$T_{1/2}$	E_γ (keV)	η (%)	cross section (mb) experimental	cross section (mb) predicted
^{54}Fe(n, p)^{54}Mn	312.5 d	834.8	100	358±22	334.
^{59}Co(n, p)^{59}Fe	44.6 d	1099.3	56	53.1±4.5	72.1
^{58}Ni(n, p)^{58}Co	70.78 d	810.6	99.4	338±26	392.
^{60}Ni(n, p)^{60g}Co	5.272 y	1332.5	100	134±11	
^{92}Mo(n, p)^{92m}Nb	10.13 d	934.5	95.5	71.8±5.7	
^{95}Mo(n, p)^{95g}Nb	35.1 d	765.8	99	44.8±3.5	
^{54}Fe(n, α)^{51}Cr	27.71 d	320.1	9.8	84.0±7.5	123.
^{62}Ni(n, α)^{59}Fe	44.6 d	1099.3	56	25.8±3.3	17.8
^{98}Mo(n, α)^{95}Zr	65.5 d	756.7	54.6	8.1±0.8	4.88
^{59}Co(n, $2n$)^{58}Co	70.78 d	810.6	99.4	752±60	
^{96}Zr(n, $2n$)^{95}Zr	65.5 d	756.7	54.6	1639±128	
^{58}Ni(n, np)^{57}Co	271 d	122.1	85.6	373±29	

η: Intensity of γ-rays per disintegration

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